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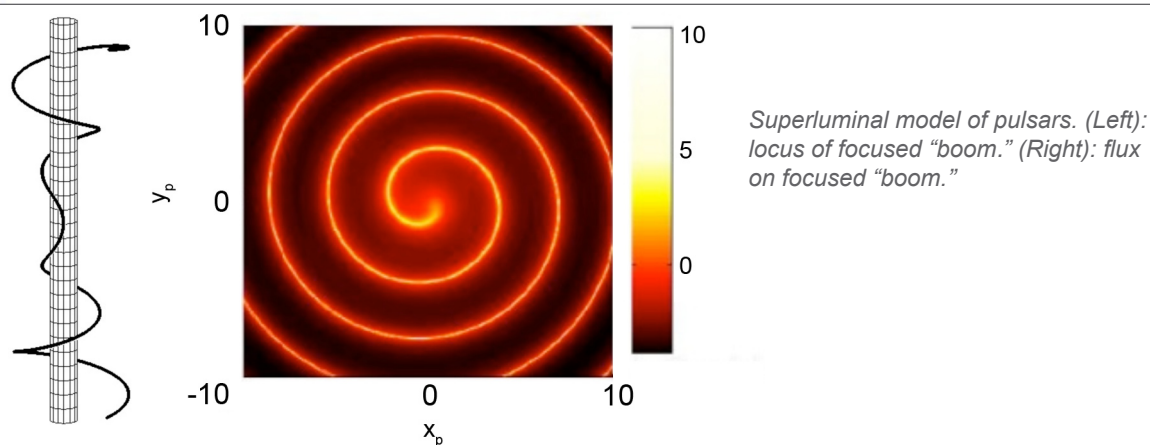
HEADS UP!

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SPOT AWARDS

Superluminal polarization currents in pulsars and on Earth

Pulsars are rotating neutron stars that emit amazingly regular, short bursts of radio waves. Though their discovery more than 40 years ago was widely reported and resulted in a Nobel Prize, the reasons how and why they send these bursts have remained a mystery.



The Los Alamos Laboratory Directed Research and Development (LDRD) project, "Construction and Use of Superluminal Emission Technology Demonstrators with Applications in Radar, Astrophysics, and Secure Communications" (John Singleton, principal investigator), is addressing the science of this phenomenon and potentially useful technical applications. The comprehensive project comprises 1) studies of superluminal sources in astronomy and astrophysics, 2) mathematical/computational studies of superluminal sources, and 3) design and construction of practical machines for applications in radar and communications. In this context, "superluminal" means a source of radiation that travels faster than the speed of light in a vacuum.

During an American Astronomical Society meeting in Washington, D.C., Singleton (MPA-CMMS) and Andrea Schmidt (AET-2) provided detailed analyses of observational data indicating that pulsars emit the electromagnetic equivalent of the well-known "sonic boom" from accelerating supersonic aircraft. Just as the "boom" can be very loud a long way from the aircraft, the analogous signals from the pulsar remain intense over very long distances. This work was conducted in collaboration with J. Middleditch (CCS-3), T. Graves (CCS-6), P. Sengupta and J. Fasel III (AET-2), H. Ardavan (Cambridge University, UK), and A. Ardavan (Oxford University, UK).

Schmidt and Singleton's presentations provide strong support for a pulsar emission mechanism—known as the superluminal model—arising from circulating polarization currents that travel faster than the speed of light. These superluminal polarization currents are disturbances in the pulsar's plasma atmosphere in which oppositely-charged particles (electrons and ions) are displaced by small amounts in opposite directions. The neutron star's rotating magnetic field causes this movement.

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From Toni's Desk



During the last week of January, Susan Seestrom, ADEPS, pulled together her leadership team for a two-day Safety Leadership Summit to brainstorm how to make significant improvements in our approach to safe work practices. Susan indicated she wanted a safety retreat early in the fall, sensing that EPS needed more focus on safety. The specific topics in this retreat were motivated both by the unacceptably high accident/injury/near-miss rate in the R&D environment in EPS and the Laboratory and by a number of recent safety incidents where analysis indicated that inadequate hazard identification/mitigation was a root cause of the incident. Below, I provide a description of the retreat and the preliminary set of actions in which we will engage. This is really a work in progress and will require everyone's participation for MPA to succeed. I welcome more ideas along these lines and/or comments on our ideas.

On the retreat's first day, Susan's management team met with Chris Cantwell, associate director for Environment, Safety, Health and Quality, and Todd Conklin, the Lab's expert on Human Performance Improvement as applied to ES&H, to determine where we need to focus our efforts for safety improvement. We spent some time going over statistics on injuries in ADEPS. Certainly both within MPA, as well as EPS, our injury rate is increasing, not decreasing as one would hope. I believe a part of this is that people are more willing to report injuries (which is good), but another component may be that people are distracted by too many things and are not able to focus on their work as well as they have in the past (which is bad). We also noticed that the number of laboratory-related ergonomic injuries is significant and increasing. Therefore, when planning your work, it is important to think about the ergonomic consequences of any repetitive actions involved.

Our discussion then led to the need to understand and prevent circumstances leading to injuries. In order to accomplish this effectively, we must learn the maximum amount from every action leading to an injury or, more importantly, a near miss. Therefore, we

require an approach that encourages reporting of near misses, but does not "punish" an employee, even in terms of extra bureaucracy or paperwork, for prompt reporting. Todd Conklin described the 40-year-old ASRS aviation safety system that allows pilots to report their own near misses and errors without fear of consequences from the FAA. This program was instituted when aviation safety was at its nadir and it led to substantial improvement because the increase in aviation safety gained by such reporting outweighed the need for discipline following safety violations. This sort of mechanism may well be required at the Laboratory to enable us to sufficiently learn from our mistakes in order to be able to significantly improve the safety of our workers. In any case, we all agreed that gathering data on near misses is essential for safety improvement.

Next, we tackled the issue of what processes within Integrated Work Management (IWM) need improvement. Several themes surfaced in this discussion: inadequate hazard identification and the necessary engagement of subject matter experts (SMEs) in the IWM process; inadequate communication between workers, especially on a large, cross-organizational team, and between workers and their management; communications with and the role of the FOD; understanding the evolution of work processes; and planning for system or performance or process variability. Lack of trust between management and workers on safety issues resurfaced as a barrier to safety improvement. As a path towards addressing this issue, we decided we need to create an environment where the workforce is engaged in safety improvements.

During the retreat's second day, first line managers (team leaders), deputy group leaders, and group leaders joined division leaders for the morning to examine issues in the specific areas of chemical, radiation, laser, electrical, and explosives safety. Both issues and best practices in each of these areas were presented and examined, including ideas on peer review/SMEs, training and authorization, optimizing facility interactions, the value of checklists, and the reporting of near misses. I co-led the laser safety discussion and found the interaction to be very constructive. The results from these discussions will be implemented where appropriate. Further, there were group leaders and division leaders who remained in the afternoon with the goal of creating processes that engage the workforce in improving work control. Ideas resulting from this meeting included: group-based peer walk-arounds to provide a fresh perspective to ongoing activities; an IWD renewal process that involves both SME review and participation by the whole team accessing that IWD; a daily job briefing for high hazard operations; a plan of the week meeting for chemical synthesis activities; and the development of a list of SMEs within ADEPS who are available to help with safety issues. We also had a discussion

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Desk... on our obligation to provide sound mentoring and training in the safety arena for students, postdocs, and indeed, all new workers.

Ultimately, the success of our attempts to improve safety will depend on all of us working together in a sustained effort to identify potential improvements and to implement them. We need your ideas and help, and your group leaders have already started to engage you in group meetings. Please think seriously about what has been proposed, as well as other things we might try. We need to implement some ideas soon, but the moral imperative is that we continue to improve and work to ensure people don't get hurt. Let your group leaders know what you think will work, and what you think needs to be done differently to work. David and I are also open to your ideas—our success depends on them.

On another note, I would like to congratulate Karen Kippen and her communications team for producing award-winning MPA newsletters. Our *Materials Matters* for January, February, and March 2009 won the Distinguished Technical Communication Award in the 2009 Society for Technical Communications competition, sponsored by the STC East Tennessee Chapter, and which included entries from international and national organizations, including other national laboratories.

—MPA Division Leader Toni Taylor

Superluminal... Although the polarized region can move faster than the speed of light in a vacuum, the velocities of the charged particles that compose these regions do not. Thus Einstein's theory of Special Relativity is not violated. In the 1980s, Nobel laureate Vitaly Ginzburg and colleagues showed that such faster-than-light polarization currents would act as sources of electromagnetic radiation. Since then, Houshang Ardavan of Cambridge University and collaborators at LANL have developed the theory (see figure). The electromagnetic "boom" spirals out from the pulsar and reaches Earth in a very short, intense pulse as a result of focusing in the time domain. Unlike subluminal sources, superluminal sources can make multiple contributions to the electromagnetic fields received at an instant by an observer. Although an observer on Earth perceives the pulsar's radiation in a very short time period, the radiation had been emitted over a much longer period of source time. This single model seems to account for all aspects of pulsar radiation.

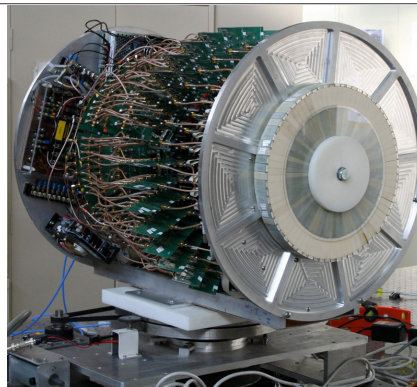
In the superluminal model of pulsars, the polarization current moves in a circular orbit. Consequently, its emitted radiation is, in some ways, analogous to that of synchrotron radiation facilities. In other words, the pulsar is a very broadband source of radiation. However, the fact that the source moves faster than the speed of light results in a flux that oscillates as a function of frequency. Schmidt showed that these predicted oscillations are observed in data from the

Crab pulsar and eight other pulsars in electromagnetic frequencies ranging from the radio waves to x-rays. In each case, the superluminal model accounts for the entire data set over 16 orders of magnitude of frequency with essentially only two adjustable parameters. A single emission process can account for the whole of the pulsar's spectrum.

Another prediction of the superluminal model for pulsars is that there should be a component of the pulsar's flux that decays as $1/d$ distance, rather than as the conventional inverse-square law. The effect is a general property of sources that both exceed the speed of their emitted waves and accelerate, and has been known in the field of acoustics since the advent of supersonic aircraft. It results from focusing of the emitted waves in the time domain. In pulsars, the acceleration is centripetal because the superluminal polarization current rotates with the neutron star's magnetic field. Singleton and collaborators analyzed flux and dispersion data from 971 pulsars. The analysis shows that pulsars possess a flux that decreases as the inverse of the distance, rather than the inverse of the distance squared. Thus the pulses are a natural electromagnetic equivalent of a well-known phenomenon in acoustics.

Generation of superluminal currents during experiments on Earth validate the model. Several ground-based demonstrations of the principle have been carried out in the United Kingdom, Russia, and the U.S. A team consisting of Dale Dalmas, Larry Earley, Ian Higginson, Frank Krawczyk, Quinn Marksteiner, John Quenzer, Bill Romero, and Zhi-fu Wang (ISR-6); and Singleton designed, built, and tested the Los Alamos machine in the photo. This machine makes a polarization current travel in a circular path at speeds of up to six times the speed of light. The polarization current behaves much like a conventional current in that it emits electromagnetic radiation.

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The Los Alamos machine, which is used to study polarization current at superluminal speeds. The polarization current runs around the circular assembly of 72 alumina (white) elements on the end of the machine. The amplifiers (green) individually polarize the alumina elements with carefully controlled phases and voltages. It is the phase differences between these amplifiers that enable scientists to control the speed at which the current circulates.

Superluminal... However, there are two important differences: (1) the polarization current can travel much faster than the speed of light, and (2) it is a true volume current, rather than a surface current. The machine is thus a completely new type of antenna, called a "light slinger." It has a number of useful research and development functions: it simulates the emission of radiation by pulsars, it acts as a technology demonstrator for applications of superluminal sources in radar, long-range, low-power communications and medicine; and it validates the complex mathematics used to simulate superluminal sources. The machine is presently in use at ISR-6. Soon it will travel to Kirtland Air Force Base for extensive experiments in a very large anechoic chamber (shielded room designed to eliminate reflected electromagnetic energy).

Multielectron oxidation photocatalysis harvests solar energy to produce chemical fuels

The potential use of sunlight energy to drive challenging reactions, such as the photochemical activation of small molecules and the splitting of water into hydrogen and oxygen, has received a great deal of interest because of its relevance to the renewable production/conversion of solar fuels and future carbon-neutral energy technologies. A major bottleneck in research related to "artificial photosynthesis," however, has been the technical difficulty in developing an efficient photocatalyst that satisfies the demanding thermodynamic and kinetic requirements for carrying out such energetically uphill and mechanistically complex multi-electron/multi-proton transformations.

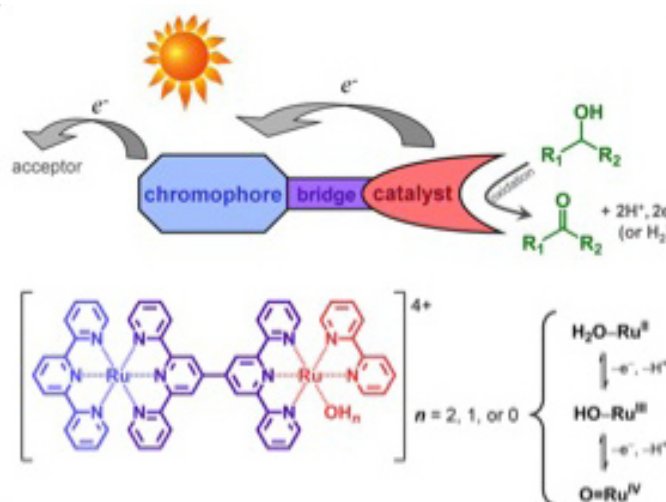
As an important step in this direction, Reginaldo Rocha and postdoctoral researcher Weizhong Chen (both MPA-CINT) and Francisca Rein (C-PCS) used molecular chemical approaches to construct a modular chromophore-catalyst dyad assembly of ruthenium complexes. The assembly successfully coupled single-photon absorption/excitation with multi-electron/proton transfer reactivity for the catalytic photooxidation of organic substrates. For example, under simulated solar irradiation in the visible spectral region, the photoactivated dyad in water (at ambient temperature and pressure) catalytically performs the 2-electron/2-proton dehydrogenation of a series of aliphatic and benzyl alcohols into the corresponding aldehydes or ketones (see figure). The total selectivity and high activity (hundreds of turnover cycles) in a homogeneous fashion are remarkable.

Angewandte Chemie, the highest-impact chemistry journal, published this unprecedented demonstration (Reference: "Homogeneous Photocatalytic Oxidation of Alcohols by a Chromophore-Catalyst Dyad of Ruthenium Complexes," *Angewandte Chemie International Edition* **48**, 9672 [2009]).

The proof-of-concept work represents a significant advance in photocatalysis toward the development of supramolecular systems for solar production of chemical fuels. There are also potential applications for environmentally friendly reactions in oxidative organic processes ("green chemistry"). The team Rocha leads is now focused on both the modification of such assemblies to incorporate the capability for water oxidation and the attachment of the molecular photocatalysts onto appropriate semiconductors to test their performance as heterogeneous photocatalytic nanomaterials. Of particular interest in such oxidative conversions is that the anodic release of protons and electrons from the photooxidation of organics or water can be integrated with recombination at a cathodic terminal for H₂ fuel production in a photoelectrochemical cell.

The Los Alamos Laboratory Research and Development (LDRD)–Directed Research project "Biomimetic Hydrogen Production by Photoinitiated Transition Metal Catalysis" (Principal Investigator Rocha) supported the research. Other work related to the oxidation module of the LDRD project includes spectroscopy [Dana Dattelbaum (DE-9), Brian Dyer (C-PCS), Donny Magana, David Morris, and Andy Shreve (all MPA-CINT)]; and theory [Enrique Batista, Elena Jakubikova, and Rich Martin (all T-1)].

Technical contact: Reginaldo Rocha



Schematic illustration of the oxidation of alcohols by the catalytic module of the dyad assembly upon its activation accompanying sequential repetition of the visible-light absorption/photoexcitation at the chromophoric unit and stepwise electron transfers from the reaction site toward the acceptor.

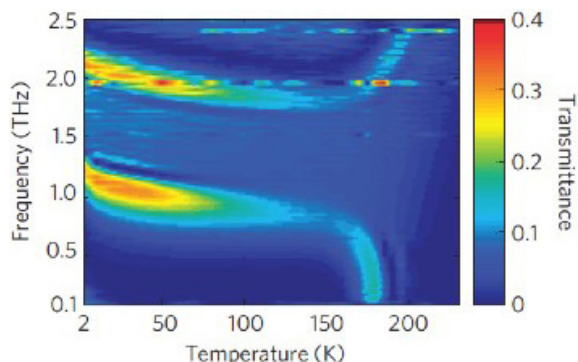
Interference-induced terahertz transparency

Maximum modulation of light transmission occurs when an opaque medium is suddenly made transparent. This effect can occur in atomic and molecular gases through different mechanisms, but the phenomenon is relatively unexplored in solids.

Scott Crooker (MPA-CMMS) and collaborators from Rice University and Texas A&M University used coherent terahertz spectroscopy to reveal a thermally and magnetically induced transparency in a semiconductor-based plasma. They observed a sudden appearance and disappearance of transmission through electron-doped indium antimonide (InSb) over narrow temperature and magnetic field ranges (see figure). Coherent interference between left- and right-circularly polarized terahertz eigenmodes caused the phenomenon. This is analogous to the way polarized sunglasses interfere with visible light. Excellent agreement with theory reveals long-lived coherence of magneto-plasmons. Coherent interference phenomena, which are commonly observed and used in the visible and near-infrared range, can thus be extended into the terahertz regime.

The free electrons in the conduction band of doped narrow-gap semiconductors behave as classic solid-state plasmas. Because of the low electron densities achievable in these materials and the electrons' small effective mass and high mobility, most of the important energy scales (cyclotron energy, plasma energy, Fermi energy, donor transition energies, etc.) can all lie within the same narrow energy range from about 1-10 milli-electron-volts, or the terahertz frequency range (1 THz is equivalent to 4.1 meV). The interplay between these material properties, which are tunable with magnetic field, doping density and/or temperature, make doped narrow-gap semiconductors a useful material system in which

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Temperature dependence of THz transmittance spectra for lightly electron-doped InSb in a magnetic field of 0.9 tesla.

HeadsUP!



Temporary government parking placards issued in 2009 remain usable

Pending review and revision of the Parking Procedure (P908), all temporary government parking placards issued in 2009 will remain usable. The placards were issued to Laboratory organizations for use by drivers of private vehicles engaged in official Laboratory business. The placards are light purple and laminated, with an expiration date of 12/31/2009. All organizations may continue to use the placards until further notice.

Enforcement of private vehicle parking violations

Los Alamos now has a full-time Los Alamos Police Officer writing tickets for parking and other violations for private vehicles. If you are issued a ticket you must appear before the county magistrate. For government vehicles SOC will write tickets.

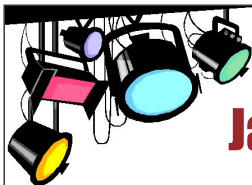
Areas of focus for private vehicles

- Handicap parking spots: Please ensure you placard is visible or you will receive a parking ticket.
- Private vehicles in government spots.
- Loading zones: Don't park more than 20 minutes.
- Two-hour visitor parking: Don't park more than two hours
- Parking in a tow-away zone will result in a ticket, towing, and impound of your vehicle.

Areas of focus for government vehicles

- Handicap parking spots.
- Assigned government-vehicle parking spots.
- Loading zones: Don't park more than 20 minutes.
- Two-hour visitor parking: Don't park more than two hours
- Parking in a tow-away zone will result in a ticket, towing, and impound of the government vehicle.

Please park private and government vehicles legally. Also, please drive safely and responsibly around the Lab and to and from work.



January spot awards!

MPA-CINT

Kevin Baldwin: prompt response to fire safety issues

Lisa Phipps: increased awareness of the VPP program and it's introduction at Los Alamos

Emily Schmidt: biosafety/nanomaterials safety

MPA-CMMS

Carmen Espinoza: excellence in chemical management

Mike Gordon: electrical safety

MPA-MC

Tony Burrell: chemical safety/incident investigation

Gary Hagermann: prompt and effective response to safety issues surrounding snow removal

MPA-STC

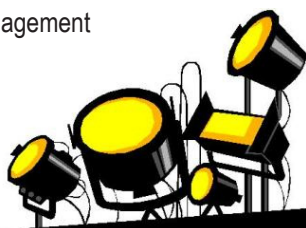
Jack Kennison: clean up legacy chemical waste

MPA-11

Christopher Dudley: excellent housekeeping

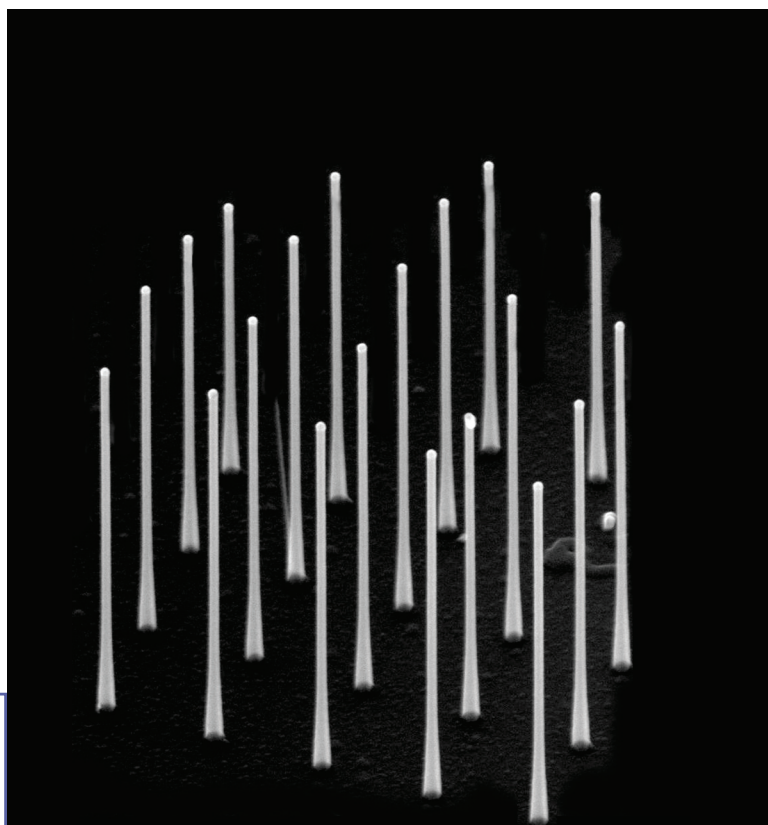
Cathy Padro: preparation for holiday shutdown

Pat Turner: pressure safety, waste management and chemical safety



Terahertz... to probe and explore new phenomena that can be exploited for future terahertz technology. The observed interference phenomena depend sensitively on plasma properties and carrier interaction, and could be used to study solid-state plasmas over a vast range of external fields and temperatures from the classical limit to the ultra-quantum limit. Potential applications for terahertz technology include imaging, spectroscopy, communications, and switching. Reference: "Interference-induced Terahertz Transparency in a Semiconductor Magneto-plasma," *Nature Physics*, Advanced Online Publication (December 2009). The National Science Foundation and the Robert A. Welch Foundation supported the work.

Technical contact: Scott Crooker



A scanning electron micrograph of a regular array of epitaxially grown vertical germanium nanowires with small gold seeds at their tip. These single crystal <111> oriented nanowires are self-assembled by vapor-liquid-solid growth and are being investigated for their novel electronic properties.

MPA MaterialsMatter

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To read past issues see
www.lanl.gov/orgs/mpa/materialsmatter.shtml



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